S'C'T

Post Launch
Mission Operation Report
No. S 868-78-03
August 16, 1979

TO: A/Administrator

FROM: S/Associate Administrator for Space Science

SUBJECT: International Ultraviolet Explorer (IUE)
Post Launch Report #2

The International Ultraviolet Explorer (IUE) is adjudged successful based upon the results of the mission with respect to the approved prelaunch objectives.

The IUE, an Explorer-class ultraviolet astronomy mission, is an international cooperative program between the United States, the United Kingdom (UK), and the European Space Agency (ESA) which provides for a single launch into a geosynchronous orbit to conduct spectral distribution studies of celestial and solar system ultraviolet sources. The spacecraft and scientific instrument were designed and fabricated at the Goddard Space Flight Center. The spectrograph camera system was provided by the UK; ESA provided the Solar Array as well as the European Ground Station.

The available observing time is shared roughly equal to the respective contributions, with the US having two-thirds and the UK and ESA sharing equally in the remaining one third.

The IUE observatory system was designed to functionally resemble a ground-based optical observatory at which guest observers could execute observing programs in real time. Observations are made from ground stations at GSFC and Madrid, Spain.

In the 15 months since IUE commenced routine guest observer operations on April 3, 1978, Observatory performance has substantially exceeded design and mission objectives. At high resolution, spectra of stellar sources has been obtained as faint as 12th magnitude while at lower resolution, observations have been made of extragalactic sources fainter than 17th magnitude. The latter observations required 3-axis stabilized pointings in excess of 14 hours continuously.

The secondary mission objectives have also been met. The IUE gyros have been selected for Space Telescope (ST) use; the IUE Spectrograph is a forerunner of the ST High Resolution Spectrograph; the IUE cameras have influenced the design of detectors for the ST Faint Object camera; and the IUE operational software and guest observer operations will provide an experience base for ST.

In addition to the high quality of the output, the data productivity is also great. NASA guest observers have obtained over 6000 images supporting more than 100 different research programs. The UK and ESA guest observers have produced almost 3000 images in support of 150 or so research programs. As a result, scientific results are



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being widely reported. Well over 100 papers have been presented at various meetings and symposia both in this country and abroad. By the time of the first anniversary in orbit, January 1979, 15 publications had already appeared in NATURE and the Astrophysics Journal Letters (Attachment). Many more have been published or are in preparation (Attachment 2 is a partial summary of results from NASA observers).

A summary of a selected number of the most important results obtained to date follows:

a. Discovery of mass loss in hot subdwarfs and of "cool" stellar winds in G and K supergiants.

b. Delineation of the region in the HR diagram exhibiting chromospheric phenomena.

c. Discovery of short-term variability in line profiles of OB supergiants.

d. Discovery of gold in A peculiar stars.

e. Detection of CR II in the interstellar medium.

f. Discovery of hot circumstellar shells around stellar X-ray sources.

g. Discovery of bright UV sources at the centers of some globular clusters.

h. The first ultraviolet observations of a recurrent nova indicating that the ejected mass is an order of magnitude less than for classical novae.

i. The first ultraviolet spectra of a supernova.

j. The first ultraviolet spectra of supernova remnants.

k. The first direct observational evidence of a high temperature corona about our galaxy indicating $T_e \sim 10^5$ and $N_e \sim 4 \times 10^{-4}$.

l. Observations of UV line intensities for several low and intermediate redshift QSO's; detection of continuum radiation in two high redshift QSO's down to rest wavelengths below 400 A.

m. Discovery of acetylene in the atmosphere of Saturn.

n. Discovery of ultraviolet limb brightening on the Jovian disc, requiring the existence of an extensive pure Rayleigh atmosphere.

IUE performance continues to be excellent. The only expendable limitation to IUE lifetime is the onboard hydrazine for momentum wheel unloading and station keeping. At the present usage rate, IUE could last for 30 years. All the essential spacecraft subsystems are redundant; the only failure that has occurred is in a redundant Panoramic Attitude Sensor (PAS), but the PAS is not required for in-orbit operations. Some anomalies have occurred with the onboard computer (OBC) but they have been corrected through internal reprogramming. It should be noted that during the course of the anomalies, backup and survival modes were implemented successfully.

Scientific Instrument performance has also been excellent. The only problem is with a redundant Short Wavelength Spectrograph Camera which operates intermittently. Both Long Wavelength Spectrograph cameras are operational as are both Fine Error Sensors.

In summary, the IUE is working very well and shows every expectation of continuing. The great productivity and large number of exciting and even unexpected results constitute a substantial scientific and technical achievement and give promise to future substantial scientific results.

Thomas A. Mutch

# NASA MISSION OBJECTIVES FOR THE INTERNATIONAL ULTRAVIOLET EXPLORER (IUE) MISSION

## PRIMARY OBJECTIVES

- To obtain high resolution ( ~ 0.13A) spectra in the ultraviolet region of the spectrum from 1150A to 3200A of stars and planets brighter than 7th visual magniture, for detailed analysis of stellar and planetary atmospheres in order to determine more precisely their physical charactersitics.

- To obtain lower resolution (~6A) spectra over the same wavelength range for both stellar and extended objects as faint as 12th magnitude or fainter for investigations of peculiar objects such as quasars, Seyfert galaxies, pulsars, X-ray sources, and variability phenomena to shed light on questions of cosmological significance.

## SECONDARY OBJECTIVES

- To evaluate the performance of various subsystems and components such as the spectrograph system for potential application to larger astronomical facilities such as the Space Telescope (ST).

- To provide a basis of utility and experience by combining the operations of geosynchronous observatory and a ground-based real-time observatory in order to maximize broad participation of the worldwide scientific community in this mission and to prepare for potential large telescope missions.

T. B. Norris, Director
Astrophysics Programs

Date: 1/16/78

Noel W. Hinners
Associate Administrator for Space Sciences

Date: 1/18/78

## ASSESSMENT OF THE INTERNATIONAL ULTRAVIOLET EXPLORER (IUE) MISSION

Based upon a review of the assessed performance of the International Ultraviolet Explorer (IUE) launched on January 26, 1978, this mission is adjudged successful in accordance with the prelaunch mission objectives stated above.

J. B. Norris

T. B. Norris, Director,
Astrophysics Division, Office of Space Science

Date: Aug 9, 1979

Thomas A. Mutch

Thomas A. Mutch,
Associate Administrator for Space Science

Date: 8/16/79

## IUE PAPERS FIRST YEAR IN ORBIT

"The IUE Spacecraft & Instrumentation"
A. Boggess, F. A. Carr, D. C. Evans, D. Fischel, H. R. Freeman, C. F. Fuechsel, D. A. Klinglesmith, V. L. Krueger, G. W. Longanecker, J. V. Moore, E. J. Pyle, F. Rebar, K. O. Sizemore, W. Sparks, A. B. Underhill, H. D. Vitagliano, D. K. West, F. Macchetto, B. Fitton, P. J. Barker, E. Dunford, P. M. Gondhalekar, J. E. Hall, V. A. W. Harrison, M. B. Oliver, M. C. W. Sandford, P. A. Vaughan, A. K. Ward, B. E. Anderson, A. Boksenberg, C. I. Coleman, M. A. J. Snijders, and R. Wilson, 1978, Nature, 275, 372.

"In-Flignt Performance of the IUE"
A. Boggess, R. C. Bohlin, D. C. Evans, H. R. Freman, T. R. Gull, S. R. Heap, D. A. Klinglesmith, G. R. Longanecker, W. Sparks, D. K. West, A. V. Holm, P. M. Perry, F. H. Schiffer III, B. E. Turnrose, C. C. Wu, A. L. Lane, J. L. Linsky, B. D. Savage, P. Benvenuti, A. Cassatella, J. Clavel, A. Heck, F. Macchetto, M. V. Penston, P. L. Selvelli, E. Dunford, P. Gondhalekar, M. B. Oliver, M. C. W. Sandford, D. Stickland, A. Boksenberg, C. I. Coleman, M. A. J. Snijders, and R. Wilson, 1978, Nature, 275, 377.

"IUE Observations of Hot Stars: HZ43, BD+75°325, NGC6826, SS Cygni, η Carinae" S. R. Heap, A. Boggess, A. Holm, D. A. Klinglesmith, W. Sparks, D. West, C. C. Wu, A. Boksenberg, A. Willis, R. Wilson, F. Macchetto, P. L. Selvelli, D. Stickland, J. L. Greenstein, J. B. Hutchings, A. B. Underhill, R. Viotti, and J. A. J. Whelan, 1978, Nature, 275, 385.

"IUE Observations of Cool Stars: α Aurigae, HR1099, λ Andromedae, and ε Eridani"
J. L. Linsky, T. R. Ayres, G. S. Basri, N. D. Morrison, A. Boggess, F. H. Schiffer III, A. Holm, A. Cassatella, A. Heck, F. Macchetto, D. Stickland, R. Wilson, C. Blanco, A. K. Dupree, C. Jordan, and R. F. Wing, 1978, Nature, 275, 389.

"IUE Observations of the Interstellar Medium"
M. Grewing, A. Boksenberg, M. J. Seaton, M. A. J. Snijders, R. Wilson, A. Boggess, R. C. Bohlin, P. M. Perry, F. H. Schiffer III, P. M. Gondhalekar, F. Macchetto, B. D. Savage, E. B. Jenkins, H. M. Johnson, M. Perinotto, and D. C. B. Whittet, 1978, Nature, 275, 394.

"IUE Observations of X-Ray Sources: HD153919(4U1700-37), HDE226868 (Cyg X-1), HZ Her (Her X-1)"
A. K. Dupree, R. J. Davis, H. Gursky, L. W. Hartmann, J. C. Raymond, A. Boggess, A. Holm, Y. Kondo, C. C. Wu, F. Macchetto, M. C. W. Sandford, A. J. Willis, R. Wilson, F. Ciatti, J. B. Hutchings, H. M. Johnson, J. Jugaku, D. C. Morton, A. Treves, and E. P. J. van den Heuvel, 1978, Nature, 275, 400.

"The IUE Observations of Extragalactic Objects"
A. Boksenberg, M. A. J. Snijders, R. Wilson, P. Benvenuti, J. Clavell, F. Macchetto, M. Penston, A. Boggess, T. R. Gull, P. Gondhalekar, A. Lane, B. Turnrose, C. C. Wu, W. M. Burton, A. Smith, F. Bertola, M. Capaccioli, A. M. Elvius, R. Fosbury, M. Tarenghi, M. H. Ulrich, R. L. Hackney, C. Jordan, C. G. Perola, R. C. Roeder, and M. Schmidt, 1978, Nature, 275, 404.

"IUE Observations of Solar System Objects"
A. L. Lane, E. Hamrick, A. Boggess, D. C. Evans, T. R. Gull, F. H. Schiffer III, B. Turnrose, P. Perry, A. Holm, F. Macchetto, P. M. Gondhalekar, G. E. Hunt, R. Wilson, T. C. Owen, H. W. Moos, M. G. Tomasko, T. Gehrels, R. Conway, and C. A. Barth, 1978, Nature, 275, 414.

"Electron Densities in Stellar Atmospheres from IUE Spectra"
C. A. Doschek, U. Feldman, J. T. Mariska, J. L. Linsky, Ap. J., 226, L35, 1978.

The Lσ / β/Pυ Ratio in the Quasar PG 0026+129"
J. A. Baldwin, M. J. Rees, M. S. Longair, M. C. Perryman, Ap. J. 226, L57, 1978.

"IUE Observations of the Eclipsing Binary Epsilon Aurigae"
M. Hack and P. L. Selvelli, Nature 276, 376, 1978.

"IUE Observations of Large Magellanic Cloud Members and Detection of the 2200A Feature"
K. Nandy and D. H. Morgan, Nature 276, 478, 1978.

"The Ultraviolet Spectrum and Expansion Velocity of ζ Carinae from IUE Observations"
A. Cassatella, A. Giangrande, R. Viotti, Astron. and Astrop. 71, L9, 1979

"UV Spectrum of Supernova Remnant Reveals Carbon Depletion in the Interstellar Medium"
P. Benvenuti, S. D'Odorico, M. A. Dopita, Nature, 277, 99, 1979.

"An Ultraviolet Spectrum of the High Redshift Quasar Q2204-408"
R. Wilson, D. J. Carnochan, P. M. Gondhalekar, Nature, 277, 457, 1979.

## IUE PAPERS - NASA GUEST OBSERVERS

"The Semi-torrid Gas Observed in the Director of $\gamma^2$ Velorum and the Gum Nebula"
F. C. Bruhweiler, Y. Kondo, and G. E. McCluskey, Jr., 1979, Ap. J., 229, L39

"Outer Atmosphere of Cool Stars. I. The Sharp Division into Solar-Type and Non-Solar Type Stars"
J. L. Linsky and B. M. Haisch, 1979, Ap. J. 229, L27

"Detection of Acetylene in the Saturnian Atmosphere Using the IUE Satellite"
H. W. Moos and J. T. Clarke, 1979, Ap. J. 229, L107

"Ultraviolet Spectrophotometry of Degenerate Stars"
J. L. Greenstein and J. B. Oke, 1979, Ap. J. 229, L141

"IUE Observations of the Quasar 3C273"
A. Boggess, E. Daltabuit, S. Torres-Peimbert, F. B. Estabrook, H. D. Wahlquist, A. L. Lane, R. Green, J. B. Oke, M. Schmidt, B. Zimmerman, D. C. Morton and R. C. Roeder, Ap. J. 230, L131, 1979.

"IUE Spectra of the Nuclei of M31 and M32"
H. M. Johnson, Ap. J. 230, L137, 1979.

"IUE Low-Dispersion Spectra of Four Luminous Stars with Symmetric Nebulae"
H. M. Johnson

"Ultraviolet Observations of AM Herculis with IUE"
J. C. Raymond, J. H. Black, R. J. Davis, A. K. Dupree, H. Gursky and L. Hartmann, T. A. Matilsky, Ap. J. 230, L95, 1979

"IUE and Visual Spectrophotometry of 3C120 and Markarian 79"
J. B. Oke and B. Zimmerman

"Ultraviolet Spectroscopic Measurements of Globular Clusters"
A. K. Dupree, L. Hartmann, J. H. Black, R. J. Davis, T. A. Matilsky, J. C. Raymond, and H. Gursky, Ap. J. 230, L89, 1979

"Observational Evidence for a Hot Gaseous Galactic Corona"
B. D. Savage and K. S. de Boer, Ap. J. 230, L77, 1979

"IUE Observations of Venus: Identification of the Ultraviolet Nightglow"
P. D. Feldman, H. W. Moos, and J. T. Clarke

"Outer Atmosphere of Cool Stars. II. IUE Spectra and Transition Region Models for Alpha Centauri A and B"
T. R. Ayres and J. L. Linsky

"On the Energy Distribution in Sirius B"
E. Bohm-Vitense, T. Dettmann and S. Kapranidis

"The Boundary Line in the HR Diagram for Stellar Chromospheres and the Theory of Convection"
E. Bohm-Vitense and T. Dettmann

"The Effective Temperature, Radius, Rate of Mass Loss and Luminosity of P Cygni, HD190603, Kappa Cassiopeiae and Rho Leonis"
A. B. Underhill

"Outer Atmospheres of Cool Stars. III. Mg II Flux Profiles and Chromospheric Radiative Loss Rates"
G. S. Basri and J. L. Linsky

"Outer Atmospheres of Cool Stars. IV. A Discussion of Cool Stellar Wind Models"
B. M. Haisch, J. L. Linsky, and G. S. Basri.

"Chromospheres of the Active Dwarf Binaries EQ Peg and Xi Boo"
L. W. Hartmann, R. Davis, A. K. Dupree, J. Raymond, P. C. Schmidtke and R. F. Wing

"The Ultraviolet Spectrum of Comet Seargent 1978m"
M. W. Jackson, J. Rahe, B. Donn, A. M. Smith, H. U. Keller, P. Benvenuti, A. H. Delsemme and T. Owen, 1979, Astron. Astrophys., 73. L7

"Photometric Calibration of the International Ultraviolet Explorer (IUE): Low Dispersion"
R. C. Bohlin, A. V. Holm, B. D. Savage, M. A. J. Snijders, W. M. Sparks

"The International Ultraviolet Explorer Spectral Image Processing System"
D. A. Klinglesmith III, P. M. Perry, and B. E. Turnrose, Proc. SPIE 172, 279, 1979.

"Discovery of Hot Components and Very Hot Plasmas in Six Peculiar Eclipsing Binaries"
M. J. Plavec and R. H. Koch